Bridging the Gap Between Research and Operations in the National Weather Service: Collaborative Activities Among the Huntsville Meteorological Community

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1. INTRODUCTION

A major goal of the National Weather Service (NWS) is to provide improved service and products to our local communities and customers, consistent with the mission of the NWS as a federal agency. The rapid advancements in computer and communication technology have led to an explosion in the amount of weather information available to the public and private sectors. The NWS has always played a vital role in providing weather and hydrologic services, and to capitalize on new technology to further its mission it is incumbent on the NWS to "think outside the box" for new and creative ways to further serve our customers. In an effort to achieve this goal, the new Weather Forecast Office (WFO) in Huntsville, Alabama has embarked upon a pro-active training, outreach and familiarization program geared towards assessing the needs and concerns of the local users.

WFO Huntsville is slated to begin full operations in early 2003. At that time, the office will take over forecast and warning responsibilities for eleven counties in northern Alabama (Fig. 1). The southeast United States experiences a wide range of weather regimes, from severe storms and flash flooding, to significant winter events and effects from land-falling tropical storms. The establishment of WFO Huntsville within the National Space Science and Technology Center (NSSTC) has provided a unique opportunity for close and productive collaboration with atmospheric scientists at the NASA Marshall Space Flight Center (MSFC) and the University of Alabama in Huntsville (UAH). As part of this effort, the WFO will have access to satellite data products and regional model forecasts provided by NASA through its newly formed Short-term Prediction Research and Transition (SPoRT) Center.

A goal of SPoRT is to incorporate NASA technology and research into the NWS operational environment, with emphasis on improving short-term (0-24 hr) warnings and forecasts. To initiate work toward this goal, a joint symposium was held in April 2002 at NSSTC. Participants in the symposium were surveyed as a caucus to identify the most critical needs of the forecast community. This paper provides an overview of the symposium and the accompanying survey, and explores some possible future courses of action for SPoRT/NWS collaborative activities.

2. NASA-NWS SYMPOSIUM

2.1 Symposium Overview

The NASA-NWS Joint Symposium on Short-Term Forecasting and the Convective Weather Warning Process was held in Huntsville on April 9-10 2002. For a complete agenda, see *http://wwwghcc.msfc.nasa.gov/sport/sport_meetings.html*. A primary goal of the symposium was to foster interactions among researchers, operational meteorologists, and users through informal presentations and discussion sessions. To achieve this goal, organizers invited representatives from the emergency management community, private sector, research community, academia, media and operational forecasting community. The fifty-five attendees represented a cross-section of these groups, and provided for productive interaction throughout the symposium. The members of SPoRT were able to assess the needs of the operational community in order to develop a road map for future SPoRT activities.

2.2 Presentations

The introductory session began with an overview of NASA's weather research program. Other topics included an introduction to the SPoRT Center and a presentation of satellite products applicable to short-term forecasting. The focus of the presentations then shifted to local modeling efforts. Operational and research meteorologists discussed the utility of regional data assimilation and alternative initialization techniques for the enhancement of mesoscale model output.

During the afternoon session, presentations focused on the challenges of forecasting convective weather. Members of the aviation forecasting community expressed the concerns of their customers and the difficulties of providing site-specific convective forecasts. Several presentations addressed the various remote sensing tools and techniques available to the operational forecaster. The techniques included advanced precipitation estimates based on Doppler radar and satellite data and the use of the northern Alabama Lightning Mapping Array to assess storm strength and severity. The symposium concluded with a session on the changing role of the NWS and the importance of continued collaboration with partners in the media, emergency management, academic, and scientific communities. The symposium presentations are on line at the SPoRT Center Web site:
http://wwwghcc.msfc.nasa.gov/sport/sport_meetings.html.

2.3 Discussion Sessions

A major theme of the symposium was identifying ways that the research and operational communities could work together to improve the forecasts and services provided to the end user. To facilitate interaction and feedback among individuals in attendance, several open floor discussions were held during the symposium. Discussion topics ranged from methods of technology infusion into the operational environment to new products and data sets needed to enhance our customer service.

2.3.1 Partnership Issues

Dr. Bill Lapenta, meteorologist with MSFC, chaired a discussion session geared toward local modeling and data assimilation. The purpose of this session was to gauge the needs of the operational community and provide a direction for future partnership and innovations. Dr. Lapenta defined the following priority areas of the SPoRT modeling program: regional data assimilation, short-range ensemble modeling, verification initiatives, identifying "value-added" services, and forecaster training.

The potential benefits of incorporating satellite data and other remote sensing data sets in the model initialization process were discussed. In particular, Dr. Lapenta displayed the utility of the "hot start technique" (McGinley and Smart 2001; Schultz and Albers 2001) in improving timing and placement of convective precipitation in the model output.

The issue of qualitative versus quantitative verification was discussed in some detail, including the limitations of strictly quantitative calculations. An example of how misleading statistical verification can be, compared to the actual quality of the forecast, is seen in Figs. 2 and 3 (Baldwin et al. 2001). In Fig. 2 the output from forecast model 2 was much closer to the observed conditions than the output from forecast model 1. However, when viewing the statistical verification information (Fig. 3), the "poorer" output from forecast model 1 actually produced lower error values. Cases such as this indicate the weaknesses of purely statistical verification and the need for broader evaluation methods. A consensus was reached among the group that new methods of verification, or at least quality assessment, must be developed that take into account the usefulness of the forecast to the end customer.

Given proper training and context, Dr. Lapenta stressed the utility of supplemental model data and local data assimilation techniques. Some benefits of the NASA/NWS collaboration would include high-resolution short-term numerical guidance that could be incorporated into the Interactive Forecast Preparation System (IFPS), development of site-specific model products, implementation of advanced model verification procedures, and training and daily interaction.

2.3.2 Short-term forecasts of convective weather and infusion of new products

Dr. Steve Goodman, meteorologist with MSFC, and Tom Bradshaw, Science and Operations Officer (SOO) at WFO Huntsville, chaired this informative discussion. Members of the emergency management agency (EMA) stressed their need for additional pre-event information. They discussed their need for a more detailed Hazardous Weather Outlook (HWO) and better coordination between the EMA and NWS communities. Rusty Russell, EMA director for Madison County, Alabama, expressed his desire to see detailed lightning forecasts, better training for users on hydrology issues, and experimental outlook products similar to those issued by the Storm Prediction Center (SPC).

An active discussion ensued among the group concerning the current state of NWS forecasts and a look to the future. Dr. Goodman reviewed the potential benefits of using total lightning data in the warning decision-making process. Several forecasters voiced the desire for high-resolution satellite and surface observations to detect boundaries and anticipate areas of convective initiation. The issues of optimal warning lead times and the utility of probabilistic warnings were once again discussed. A consensus agreed upon the need for the NWS to "think outside the box" and to look for new and effective means to reach the customers. Members of SPoRT and WFO Huntsville stressed the need for collaboration with surrounding forecast offices in order for the initiatives to achieve their ultimate goals.

The transition from primarily text-based forecasts to a graphical and digital suite of NWS products was also discussed. With the implementation of the Graphical Forecast Editor (GFE) component of IFPS, forecasters can create a wide array of products through a single database. The attendees stressed the need of infusing the available data sets (lightning, satellite, high resolution data assimilation and models) into GFE and creating as detailed a suite of products as possible. The EMA community again expressed their desire to receive as much weather information as possible. They stated they realize the experimental nature of some of the products, and would give them their appropriate weight in the decision process.

2.3.3 Training and Integration Issues

At the conclusion of the first session, Tom Bradshaw led a group discussion concerning the infusion of new products and data sets into the operational environment. Virtually everyone in attendance noted the positive potential of the mesoscale modeling initiatives and satellite products in the forecast process. However, the two primary concerns of field forecasters were: training and integration of new data sets.

Some forecasters in attendance were not aware of some of the satellite data sets that are available. Several NWS meteorologists mentioned the underutilization of polar orbiting satellite (POES) data and their growing potential in the forecast process. Dr. Gary Jedlovec, meteorologist with MSFC, re-iterated the utility of POES data sets and the need for adequate training on the operational use of satellite products. The discussion then shifted to the overall need for improved local training and methods for incorporating the training into a shift-work environment. Also, forecasters stressed that it simply takes too long for new innovations or techniques to be integrated into the Advanced Weather Interactive Processing System (AWIPS). The operational community would like to implement a more efficient method of ingesting new data sets into the WFO forecasting environment. The attendees were encouraged to provide ideas on how these issues could be addressed by SPoRT.

2.4 Symposium survey

The NWS, along with UAH and the members of SPoRT, desire to evaluate the needs of the operational community and the end users in order to develop a roadmap for further collaboration. In order to quantify the needs of the users and operational forecasters, a survey was developed and distributed to the attendees. The survey (Appendix) consisted of a cross-section of questions ranging from short-term forecast issues to the needs of the customers.

3. SURVEY RESULTS

3.1 Overview

Seventeen surveys were completed and returned at the conclusion of the two-day symposium. The large majority (71%) of the surveys were from NWS operational personnel. The operational feedback was deemed beneficial since the research community was looking to bridge the gap between research and operations. The survey questions centered on the short term forecast issues that affect operational personnel and in turn impact the end users. Some survey questions focused on these forecast issues and the tools and data sets used to address them. Other topics included the necessity of improving and broadening NWS services to the end users, and methods for accomplishing this task. NASA has a wide array of earth science resources at their disposal. The SPoRT Center realizes the need to prioritize their efforts on the short-term forecast issues that are most pressing and urgent to the end users.

3.1.1. Individual questions

Eleven questions were included on the participant survey. The survey issues that are deemed essential for developing a roadmap for future NWS/NASA collaborative activities will be covered in some detail. The complete survey results can be located at: *http://wwwghcc.msfc.nasa.gov/sport/2002_symp_survey.html*.

Question 1 asked the respondents to address the top five short-term forecast issues affecting their area or constituency. The majority of answers centered around three major issues including convection, aviation, and QPF. In fact, over 70% of all surveys included these three issues (Fig. 4). Although these issues overlap to some degree, the accuracy of the forecast output affects a diverse group of customers. The overall theme of the responses focused on increased accuracy and predictability of mesoscale phenomena.

While the operational forecaster currently has a vast array of model and remote sensing data at his or her disposal, the desire to precisely assess the mesoscale environment has amplified a need for additional products and data sets. As indicated by the survey results, supplemental mesoscale data sets tend to be underutilized in forecast operations. This is the result of latency issues, or lack of training or knowledge on the available data sets.

Question 3 asked the respondents for ways that current products and services could be improved to better meet their needs. The majority of respondents (65%) expressed the need for real-time data access and integration of a vast array of data into one platform (i.e., AWIPS). Due to time limitations and scheduled product issuances, it is imperative for the forecaster to assess as much data as possible within a limited window of time. To achieve integration of real-time data sets is essential. Other frequent responses included model performance improvements, additional training and sharing of information, increased resolution of data sets, and the need for faster computer processing.

Although the NWS issues a large suite of products, feedback from the public and emergency management officials in Question 4 indicates a need for additional information. Every respondent stressed the need for improved forecasts of aviation hazards (Fig. 5). In particular, the need for better forecasts of cloud ceilings, visibility, precipitation timing and precipitation type were noted. Improved forecasts of QPF were also listed on 75% of the surveys. To achieve the desired forecast improvements, NWS personnel stressed the need for additional data sets (i.e. surface observations, gauge data, total lightning data).

As customer requirements for weather information change, the NWS has to assess the benefit of the suite of products and data sets currently available. Specifically, it is incumbent upon the NWS to identify new products, services, and data sets that will better address the needs of our customers. To achieve this, suggestions were received from the survey participants in Question 5. Topping the list was the need for enhanced (high resolution with local data assimilation) model data and a wider range of high-resolution satellite data to better assess the mesoscale environment (Fig. 6). In addition, many of the end users listed the need for lightning warnings and forecasts along with other area-specific text and graphical products.

To gauge the current level of collaboration among the various entities, Question 7 centered on the way users currently receive data. An overwhelming majority (88%) stated that they were primarily introduced to new products by attending conferences or symposiums (Fig. 7). Several respondents also indicated word of mouth discussions and reading research publications or memorandums was their main source of introduction to new products and innovations. It is interesting to note only 25% of the respondents listed local training initiatives as a way they have been introduced to new products. In Question 8, the need for additional conferences, face-to-face training initiatives (local and in-resident), and a central repository for training information was underscored by the attendees (Fig. 8).

The final question (Question 10) to be discussed concerned the utility of satellite data in the forecast process. The respondents stressed their desire for more streamlined access to the data sets including the timeliness and integration issues discussed earlier. Over half of the surveys also stressed the need for better training on the use of satellite data. Of the satellite data sets that are available, forecasters expressed their interest in high-resolution output to detect boundaries, data to support precipitation estimates, and atmospheric sounding data. Again, with a new suite of high-resolution NWS products being implemented, it is incumbent upon the forecaster to receive as much mesoscale data as possible.

4. ONGOING PROJECTS AND OPPORTUNITES

4.1 COMET Cooperative Project

The Cooperative Program for Operational Meteorology, Education and Training (COMET) was established in 1989 by the NWS and UCAR (University Corporation for Atmospheric Research). COMET provides financial support to universities for collaborative research projects with NWS offices (*http://www.comet.ucar.edu/*). In the summer of 2000, WFO Birmingham, in conjunction with NASA/MSFC and UAH, embarked upon a three-year COMET Cooperative project (COMET

2000) aimed at addressing two core areas of the NWS Strategic Plan (NOAA 1999): improving tornado warning lead times and reducing false alarm ratios, and improving flash flood warning detection and lead times. Central to the ongoing COMET project is the integration of an array of tools and data sets, available through NASA and UAH, generally not available to NWS offices. Specifically, the use of total lightning data, supplemental mesoscale models, and satellite data have proven quite promising in the forecast process.

Due to the proximity of the new WFO Huntsville with NASA and UAH, the interested parties plan to expand upon the current COMET project proposal to exploit all data sets and technologies available in the region. Assuming these initiatives provide positive impacts on the forecast and warning process, it is anticipated that these regional data sets could be expanded to a national scale.

4.2 Lightning Mapping Array

The core mission of the NWS is to issue warnings for the protection of life and property. The warning decision-making process remains a challenge for forecasters given the time limitations involved. Through the years, a large volume of research has focused on storm updraft strength and its association with severe weather. The limitations of radar sampling have amplified the need for additional information concerning the structure of thunderstorms. In light of these limitations, a growing area of research has centered on the use of additional remote sensing data sets to assess the storm scale environment and anticipate the onset of severe weather.

In the past several years, WFO Melbourne, Florida, and scientists at NASA MSFC and Massachusetts Institute of Technology/Lincoln Laboratory have jointly conducted research on the relationships between total lightning within thunderstorms and overall storm severity. This research was completed using a NASA-funded collaborative research tool called LISDAD - Lightning Imaging Sensor Data Applications Demonstration (Boldi et al. 1999). The LISDAD system allows for the integration of multi-sensor data including in-cloud lightning, cloud-to-ground lightning, and radar data for real-time analysis and manipulation. The initial results indicate a distinct relationship between in-cloud flash rate and trends, and the onset of severe weather (Williams et al. 1999, Hodanish et al. 1999, Goodman et al. 1999).

Through collaboration with New Mexico Tech (Rison et al. 1999, Thomas et al. 2000), a Lightning Mapping Array (LMA) consisting of ten stations, a central receiving station, and a processing station has been developed and implemented across northern Alabama (McCaul et al. 2002). With a range of nearly 150 km, the LMA can detect in-cloud lightning strikes from any storms encompassing the area from Birmingham, Alabama to Nashville, Tennessee (Fig. 9). A new second generation LISDAD II system will ingest and display LMA data, cloud-to-ground lightning from the National Lightning Detection Network (NLDN), Level II data from the Hytop, Alabama WSR-88D, and GOES visible/infrared imagery. Through the use of algorithms developed at the Massachusetts Institute of Technology/Lincoln Laboratories (MIT/LL), the LISDAD will display gust fronts and boundaries with options to diagnose individual storm cell trends (as in Fig.10) via pop-up menus.

4.3 Mesoscale Modeling

The regional modeling component of SPoRT will provide NWS operational forecasters with additional numerical guidance that supplements the National Centers for Environmental Prediction (NCEP) model suite of products. The overall goal is to improve NWS short-term forecasts associated with convective initiation and evolution, aviation hazards, and quantitative precipitation. Satellite data and all available remote sensing measurements will be used within a regional data assimilation system to enhance short-term (0-12h) numerical forecasts.

The SPoRT Center MM5 is currently configured with a 36 km CONUS domain and a 12 km nest over the southeastern United States. The model is run ten times daily. Forty-eight hour forecasts are produced at 0000 and 1200 UTC and 12-hour forecasts are produced every hour between 1400 and 2100 UTC (*http://wwwghcc.msfc.nasa.gov/sport/sport_modeling_schedule.html*). Images are provided via the Web (*http://www.ghcc.msfc.nasa.gov/Model/model_mm5.html*) and binary output is available via anonymous ftp server for ingest into AWIPS.

Figures 11 and 12 show that the SPoRT MM5 output can provide "added value" to the NCEP suite of numerical models. In this particular case from early March 2002, the SPoRT MM5 solution verified better than the Eta model in terms of the placement, timing, and relative magnitude of significant rainfall across the southeastern U.S. Bradshaw et al. (2001) demonstrated the utility of using supplemental model data in the forecast process during the Summer Convective Rainfall in Alabama Prediction Experiment (SCRAPE). During the summer of 2000, forecasters from WFO Birmingham were able to improve upon their overall quantitative precipitation forecasts (QPFs) by using MM5 output operationally.

The use of supplemental model output by WFOs continues to increase, however, a recent NWS workshop revealed only eight percent of models used in the field were initialized with a regional data assimilation system (McQueen and Hirschberg 2001). Over the next several months, SPoRT will implement the diabatic "hot start" initialization technique (McGinley and Smart 2001, Schultz and Albers 2001) to reduce model "spin-up" during precipitation events. In addition, regional satellite data assimilation will be performed within LAPS to enhance the cloud analysis and subsequent diabatic initialization. Future SPoRT modeling activities include development of a regional short-range ensemble forecast (SREF) system that will be composed of MM5, the nonhydrostatic Eta, and the Weather Research and Forecast (WRF) model systems. SREF output will be provided to forecasters in real-time for use in forecast development.

In order to supplement the regional satellite data assimilation effort within SPoRT, the NWS and its partners will attempt to garner as much real-time regional in-situ data as possible. The goal is to form a MESONET by leveraging resources from a wide range of local, regional, and state entities. With a robust mesonet in place, the initialized data and subsequent model output should aid in identification of key mesoscale features not currently resolved well by the NCEP model suite.

The Cooperative Huntsville Area Rainfall Measurements (CHARM) initiative has already proven quite valuable in the interrogation and verification of precipitation estimates across portions of northern Alabama (Jedlovec et al. 2002). Figure 13 shows the location of the daily rainfall measurements taken by volunteers in the Huntsville region with twenty sites capable of reporting in real-time. The CHARM network has been effective in normalizing precipitation estimates from surrounding radars and providing added value to the short term forecast. Figure 14 shows a case where the CHARM data were able to resolve a localized rainfall maximum not detected by either the Nashville or Hytop WSR-88Ds.

4.4 Satellite data

One of the most underutilized tools a forecaster possesses is satellite data. Static displays of satellite data and derived products can provide a host of information ranging from the position of long-wave troughs to atmospheric instability. Satellites provide measurements over the ocean where conventional measurements rarely exist, thermodynamic and stability information between coarsely spaced rawinsondes, and high-resolution cloud information during both the day and night. Animation of the satellite imagery provides a fourth dimension which is invaluable in spotting developing cloud and storm regions, mesoscale circulation patterns, and other surface and atmospheric changes which are important for accurate short term forecasting.

Through the years, NWS forecasters have relied on only a modest amount of low-resolution GOES data in a few channels as their primary source of satellite information. The use of timely high-resolution satellite data and derived products has been spotty at best because means were looking to get those data to forecasters. The Table lists satellite imagery and products potentially available at the SPoRT Center relevant to the short-term forecast problem. For GOES, this is a subset of a list reviewed by the NWS/NESDIS Satellite Products and Services Review Board (NESDIS 2002). Through collaboration with SPoRT, the NWS will seek to exploit these and other GOES imager and sounder datasets (including rapid-scan operations) and derived products to aid in the forecast process. A number of these satellite-derived parameters are also assimilated into the MM5 model (see Sec. 4.3).

A wide variety of other satellite datasets are also available in near real-time from instruments that are part of NASA's Earth Observing System. These instruments, while mostly in polar or low-inclination orbit, provide unique observational capabilities because of their high spectral and or spatial resolution. The MODerate-resolution Imaging Spectrometer (MODIS, *http://modis.gsfc.nasa.gov/*) on-board the Terra and Aqua satellites provide a broad variety of multispectral observations at resolutions as fine as 250m. Figure 15 presents a natural-color composite of three short wave channels from MODIS. This mid-morning image captures many important aspects of developing and mature convective systems. This is just one of many examples where unique observing capabilities provide an opportunity for improvement in weather forecasts across the country.

Additional instruments such as the Atmospheric InfraRed Sounder (AIRS, *http://www-airs.jpl.nasa.gov/*) and precipitation and lightning instruments on the Tropical Rainfall Measuring Mission (TRMM) will provide near real time observing capabilities to improve short-term prediction. The high spectral resolution of AIRS will provide unprecedented vertical resolution of temperature, moisture, and trace gases at about 40km spatial resolution. Along with the Advanced

Microwave Sounder (AMSU) and the Humidity Sounder for Brazil (HSB) which are flying together on the Aqua satellite, this triad of instruments will provide an all weather sounding capability in clear and cloudy regions.

4.5 Other data sources

WFO Huntsville will have access to real-time dual Doppler synthesis using the WSR-88D in Hytop and the WSR-74C at the Huntsville International Airport. The dual-Doppler analysis will provide the vertical motion and horizontal flow fields. Also, boundaries and boundary layer wind fields will be determined using the MIT/LL Machine Intelligent Gust Front Algorithm (MIGFA) and National Center for Atmospheric Research (NCAR) Tracking Reflectivity Echoes by Correlation (TREC) algorithm (Tuttle and Gall 1999), applied to the reflectivity and radial velocity data. The utility of using dual Doppler analysis for the detection and evolution of boundaries has been well documented (Riordan et al. 1995).

In addition, UAH has real-time access to the mobile integrated profiling system (MIPS). MIPS consists of a 915 MHz wind profiler, a 2 kHz Doppler sodar, a lidar ceilometer (0.905 micron), 12-channel microwave radiometer, and surface instrumentation. The 915 MHz profiler and the Doppler sodar provide high vertical resolution wind profiles along with backscattered power return information. The backscattered power profiles will provide important information on atmospheric stratification, which is useful for monitoring moisture gradients, stable layers and the Planetary Boundary Layer (PBL) inversion layer. The 12-channel microwave radiometer will return profiles of temperature and moisture density up to 10 km. MIPS will provide the forecaster with a wealth of information concerning the structure of the boundary layer processes along with storm initiation and evolution diagnostics. During the landfall of Hurricane Georges along the Mississippi Gulf Coast in 1998, the wide-ranging potential of the MIPS was demonstrated with its high-resolution boundary layer analyses (Knupp et al. 2000).

An additional meteorological data source available to the WFO Huntsville is the upper air observation facility located at the Redstone Arsenal military installation in Huntsville. Technicians at Redstone Arsenal are prepared to complete standard radiosonde releases on fairly short notice. The nearest NWS radiosonde sites to Huntsville are Birmingham, and Nashville, which are both roughly 80 statute miles from the Arsenal. To better assess the mesoscale environment across northern Alabama, WFO Huntsville will arrange for balloon releases on critical weather days. These data can then be analyzed using various methods to aid in the short-term forecast process.

5. Benefits to Operations

WFO Huntsville has a unique opportunity for close collaboration with NASA and UAH. The three entities working in partnership will be able to leverage a vast pool of resources with the goal of infusing the latest technologies and research into the operational environment. As the push for high-resolution (both spatial and temporal) forecasts gains momentum, the NWS must access all available data sets to provide the best possible services to our customers. Over the next several months, the partners involved will work to form an implementation plan that can be a **"test bed"** for other weather service offices and collaborators. Our EMA partners are eager to participate in the project, and to provide feedback on proposed products ranging from lightning forecasts and warnings to experimental severe weather outlook products. In addition, the Huntsville collaborators will continue the interaction and "science sharing" with other members of the meteorological community through additional symposia, workshops and presentations.

As outlined in the symposium survey and the NWS Strategic Plan, there is a need for improvement of weather services in several areas. In particular, the collaborative activities in Huntsville will seek to address several of these issues, including an increase in tornado warning lead times, reduction in the number of tornado warning false alarms, production of quality, high-resolution graphical products and a significant improvement in aviation terminal forecasts. **The overall key to the success of the National Weather Service is reaching and effectively serving our customers.** It is incumbent upon the NWS to leverage all available resources to meet this goal in a timely manner. The desire of WFO Huntsville, NASA, and UAH is to provide a framework for future collaborative activities that can benefit the entire nation's weather services.

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Review of Links

AIRS Home Page: *http://www-airs.jpl.nasa.gov/*
Aqua Home Page: *http://aqua.gsfc.nasa.gov/*
COMET Home Page: *http://www.comet.ucar.edu/cometprogram.htm*
MODIS Home Page: *http://modis.gsfc.nasa.gov/*
SPoRT Home Page: *http://wwwghcc.msfc.nasa.gov*
SPoRT MM5 Model Output: *http://www.ghcc.msfc.nasa.gov/Model/model_mm5.html*
SPoRT MM5 Modeling Schedule:
http://wwwghcc.msfc.nasa.gov/sport/sport_modeling_schedule.html
Symposium Survey Results: *http://wwwghcc.msfc.nasa.gov/sport/2002_symp_survey.html*
Symposium Web Page: *http://wwwghcc.msfc.nasa.gov/sport/sport_meetings.html*

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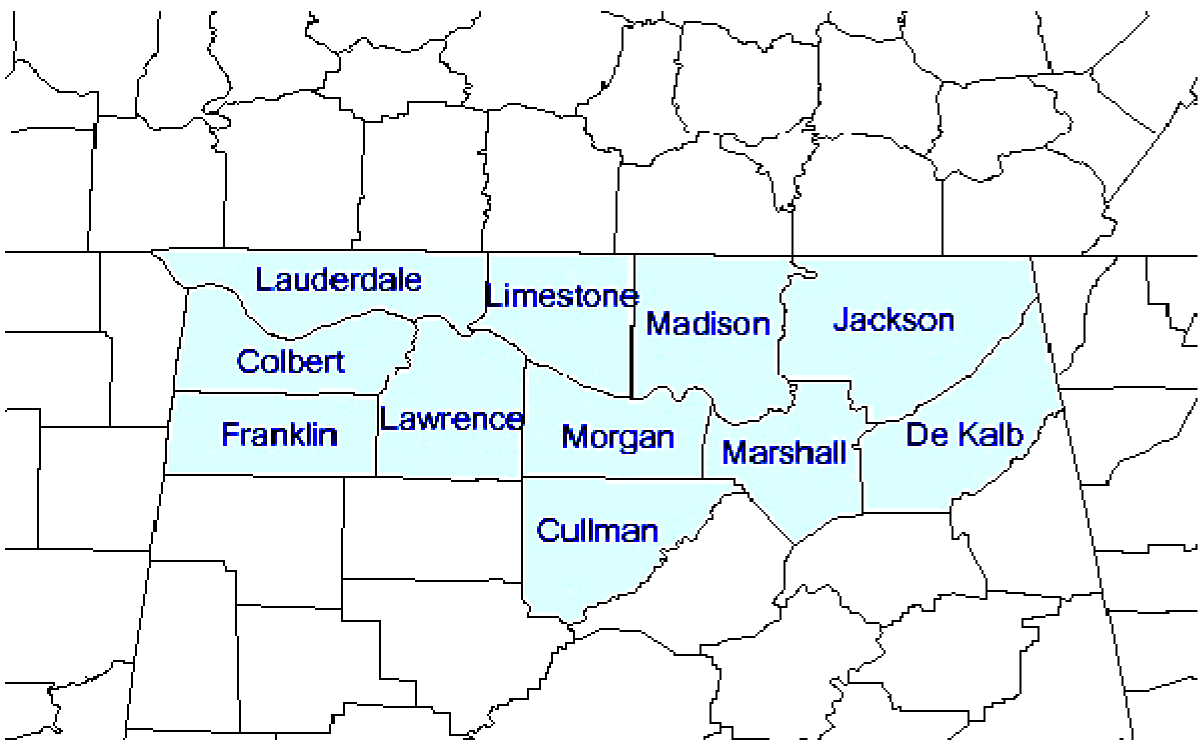


Figure 1. Map of WFO Huntsville County Warning Area.

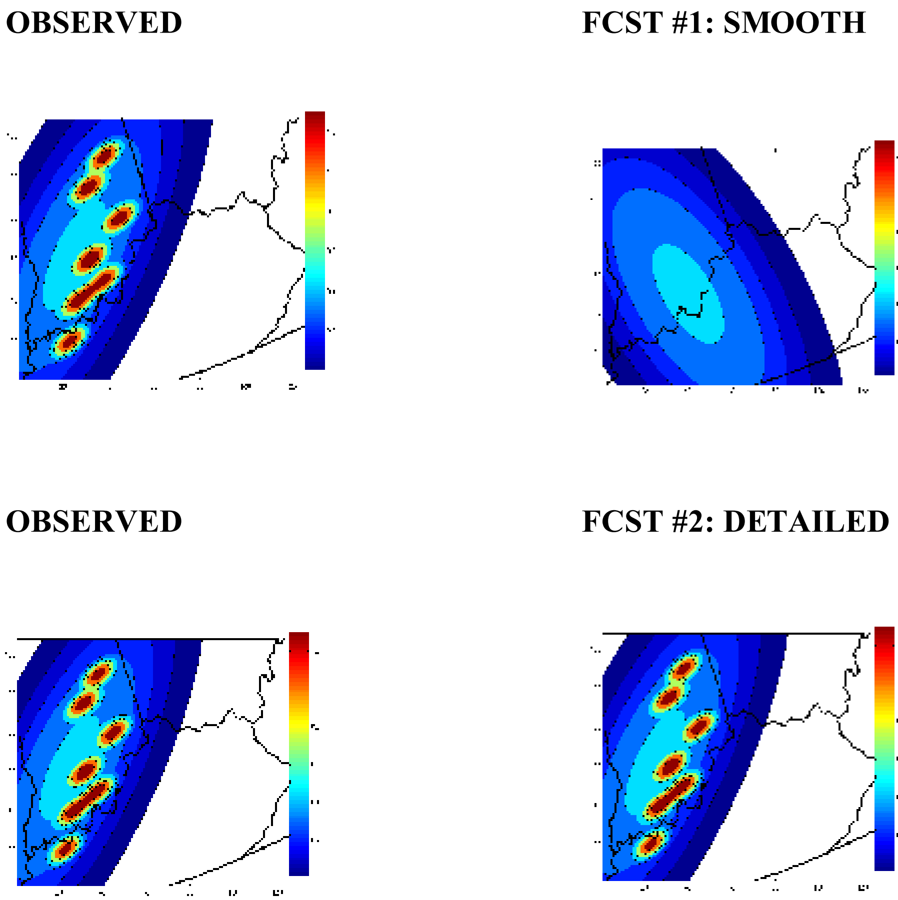
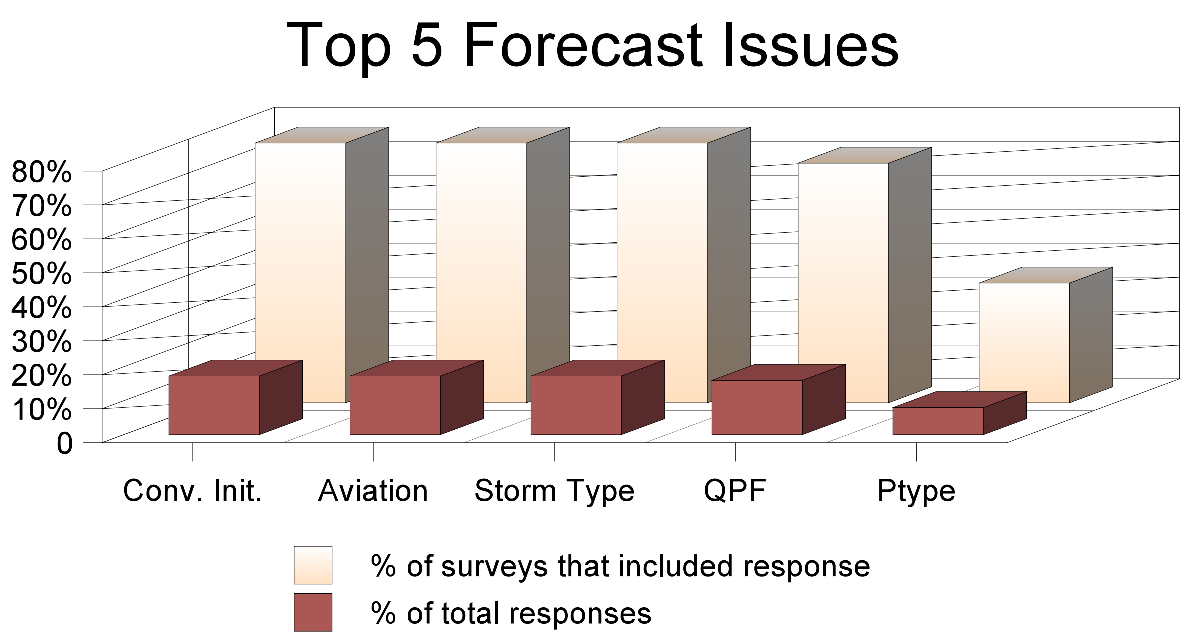


Figure 2. Comparison of two different model solutions for the same precipitation event.

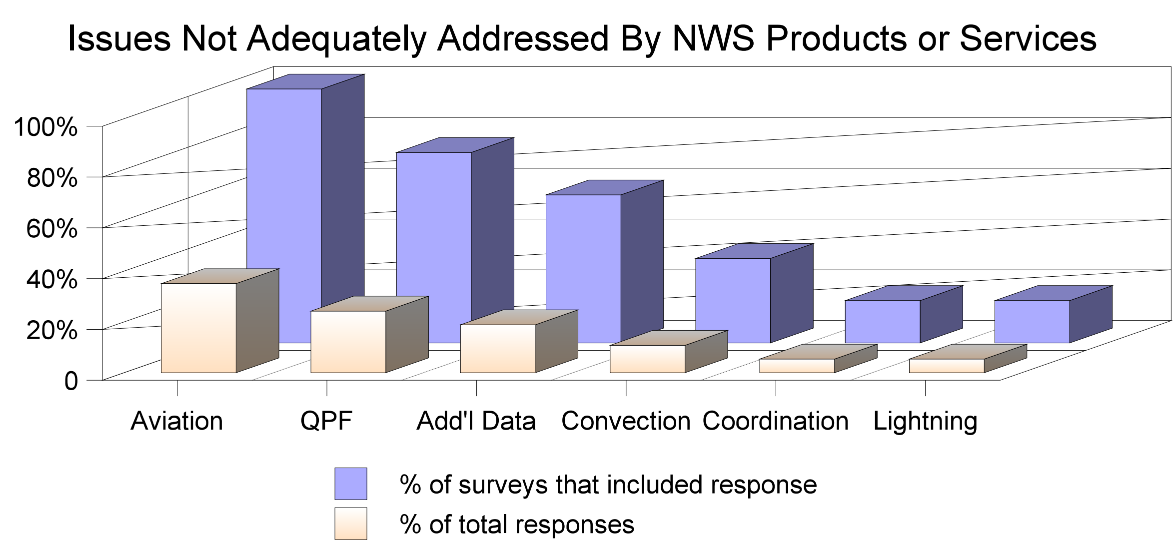
Verification Measure	Equation	Forecast #1: Smooth	Forecast #2: Detailed
Mean absolute error	$MAE = \frac{1}{n}\sum_{k=1}^{n}\lvert f_k - x_k \rvert$	0.157	0.159
RMS error	$RMSE = \sqrt{\frac{1}{n}\sum_{k=1}^{n}(f_k - x_k)^2}$	0.254	0.309
Bias	$BIAS = \overline{f}/\overline{x}$ d	0.98	0.98
Threat score (>0.45)	$TS = H/(F+O-H)$	0.214	0.161
Equitable	$ETS = \frac{H-Ch}{(F+O-H-Ch)}$	0.170	0.102

Figure 3. Statistical verification information for forecasts in Figure 2.



- Conv. Init. = Convective Initiation
- QPF = Quantitative Precipitation Forecast
- Ptype = Precipitation Type

Figure 4.



- QPF = Quantitative Precipitation Forecast
- Add'l Data = Additional Data

Figure 5.

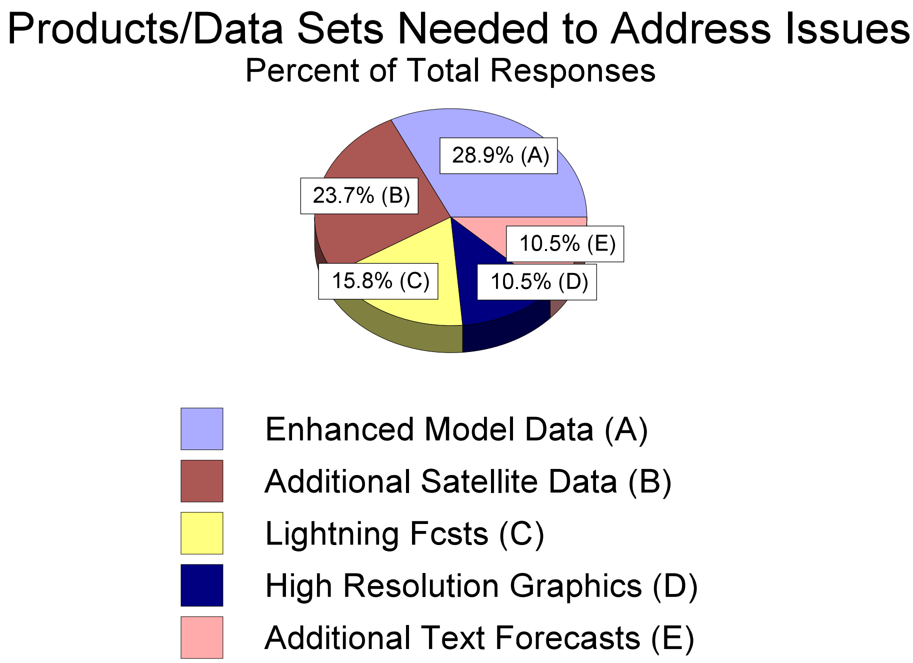


Figure 6.

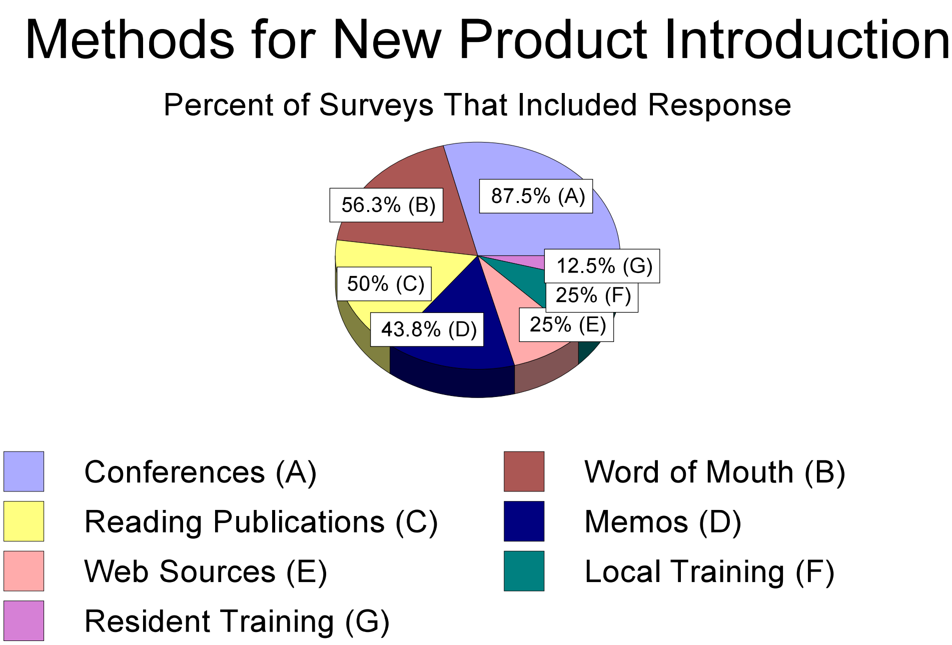


Figure 7.

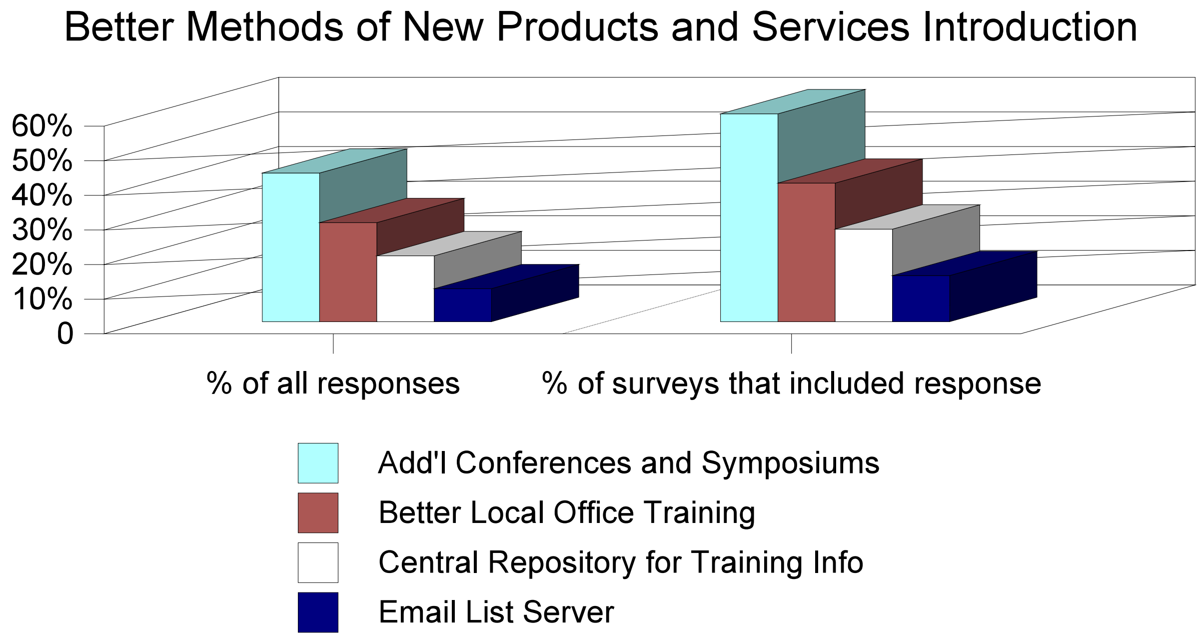

Better Methods of New Products and Services Introduction
60%
50%
40%
30%
20%
10%
0
% of all responses
% of surveys that included response
Add'l Conferences and Symposiums
Better Local Office Training
Central Repository for Training Info
Email List Server

Figure 8.

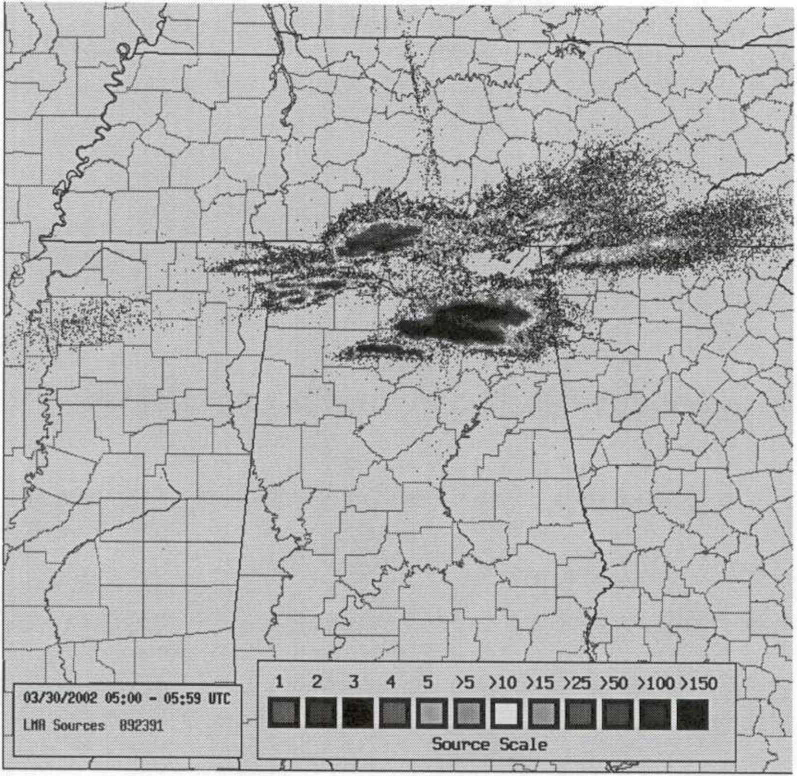

03/30/2002 05:00 - 05:59 UTC
LMA Sources 892391
1 2 3 4 5 >5 >10 >15 >25 >50 >100 >150
Source Scale

Figure 9. Sample LMA Data Set from 03/30/02.

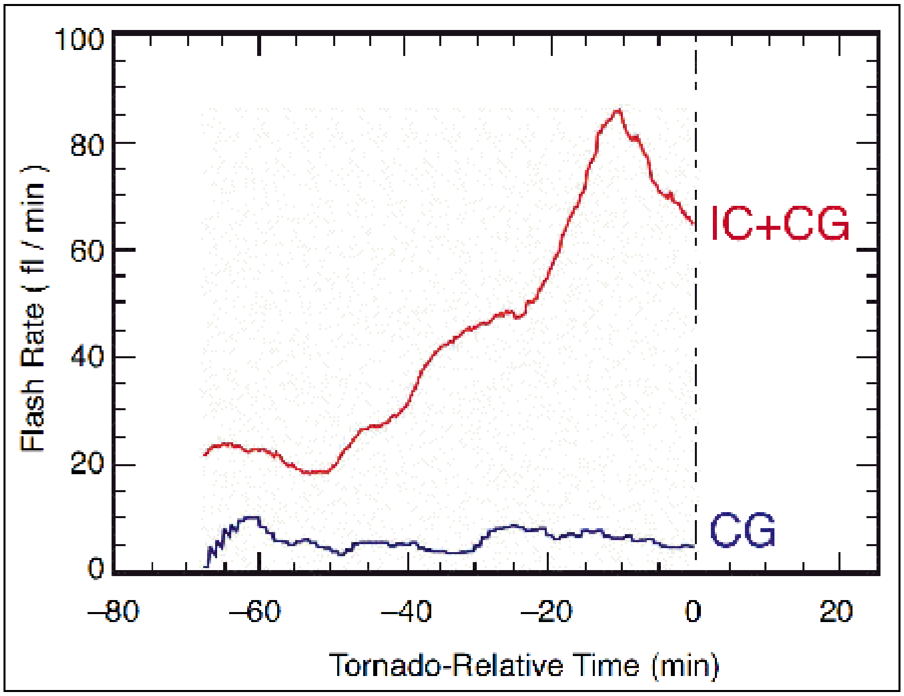


Figure 10. Total Lightning Flash Rate Tendency Relative to Tornado.

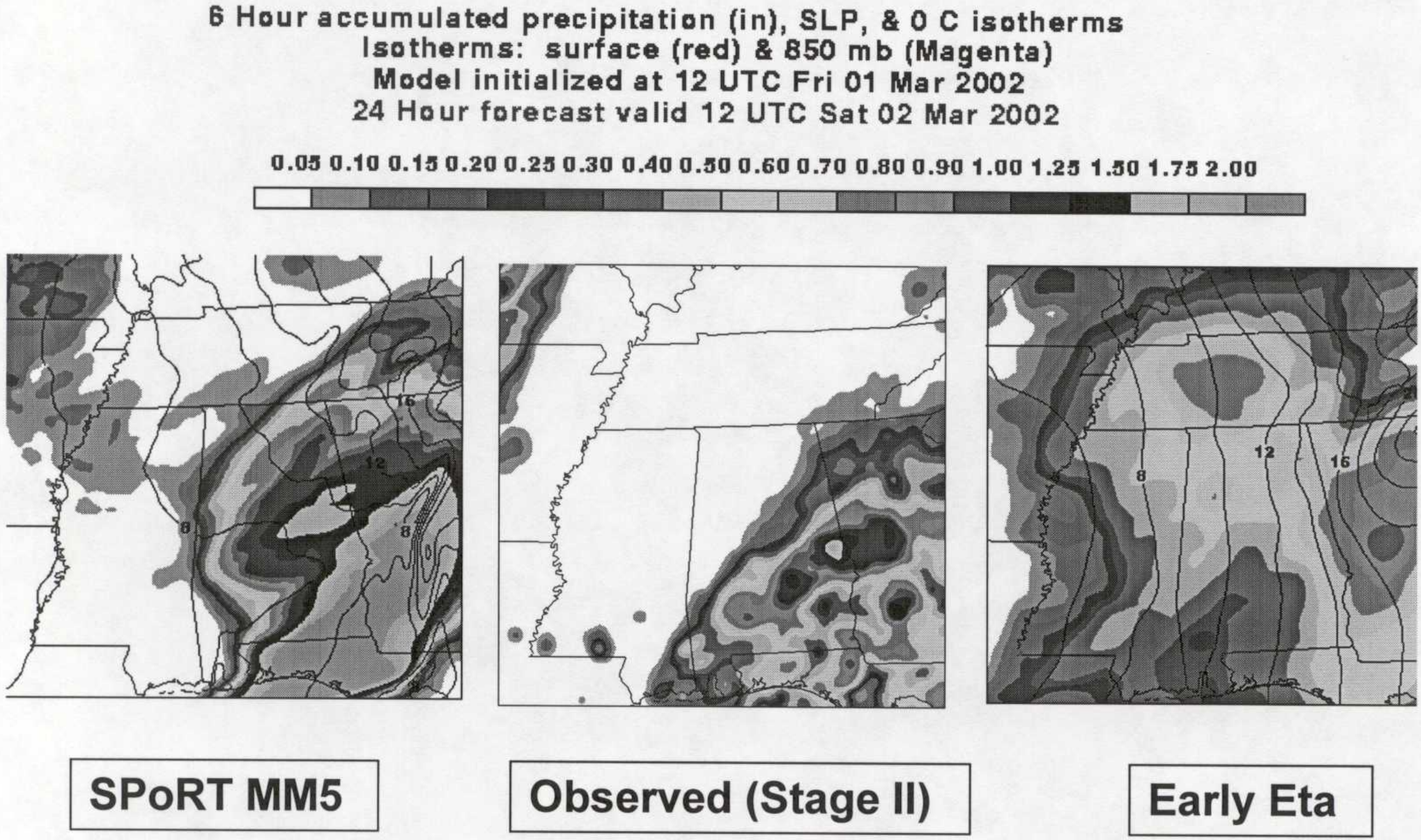
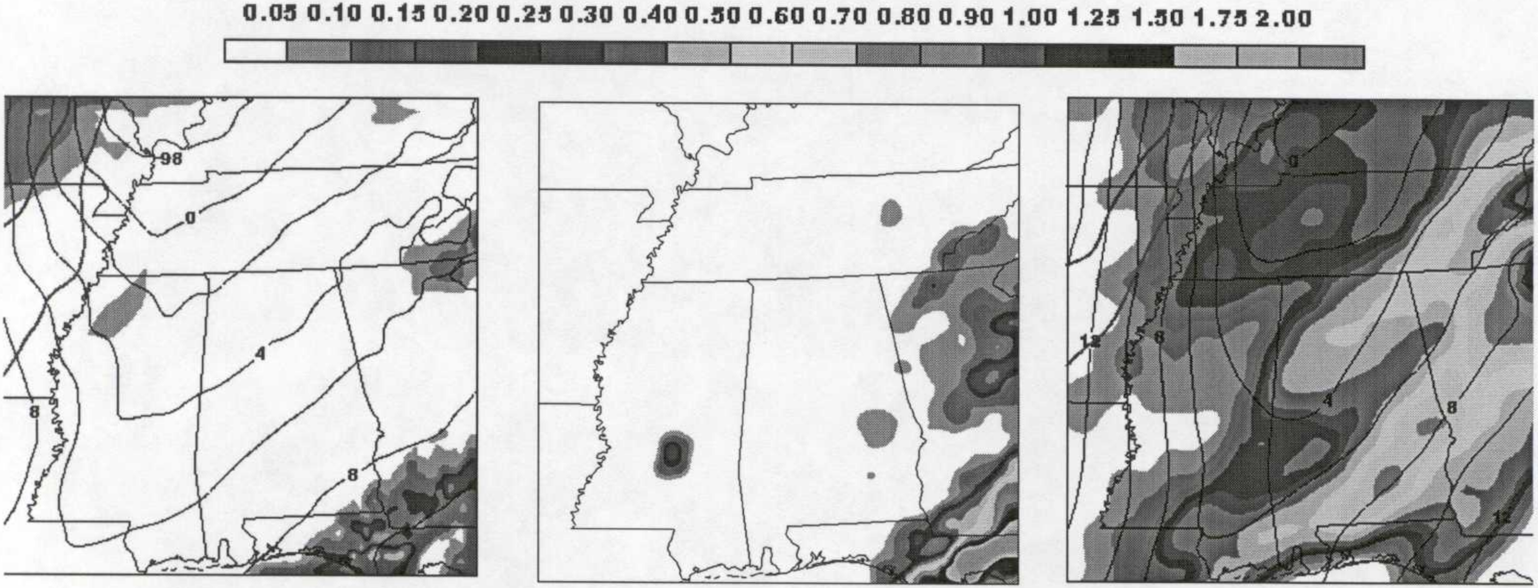

6 Hour accumulated precipitation (in), SLP, & 0 C isotherms
Isotherms: surface (red) & 850 mb (Magenta)
Model initialized at 12 UTC Fri 01 Mar 2002
24 Hour forecast valid 12 UTC Sat 02 Mar 2002
0.05 0.10 0.15 0.20 0.25 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.25 1.50 1.75 2.00
16
12
8
8
12
16
8
SPoRT MM5
Observed (Stage II)
Early Eta

Figure 11. The model output from the Early Eta and the SpoRT MM5 compared to the observed (stage II) 6-hour rainfall data. The SpoRT MM5 was able to better resolve the location and magnitude of the precipitation axis in this case.

6 Hour accumulated precipitation (in), SLP, & 0 C isotherms
Isotherms: surface (red) & 850 mb (Magenta)
Model initialized at 12 UTC Fri 01 Mar 2002
36 Hour forecast valid 00 UTC Sun 03 Mar 2002



SPoRT MM5

Observed (Stage II)

Early Eta

Figure 12. Same as in Figure 11, except 12 hours later. Again, in this case, the SpoRT MM5 provided a better precipitation forecast than the Early Eta.

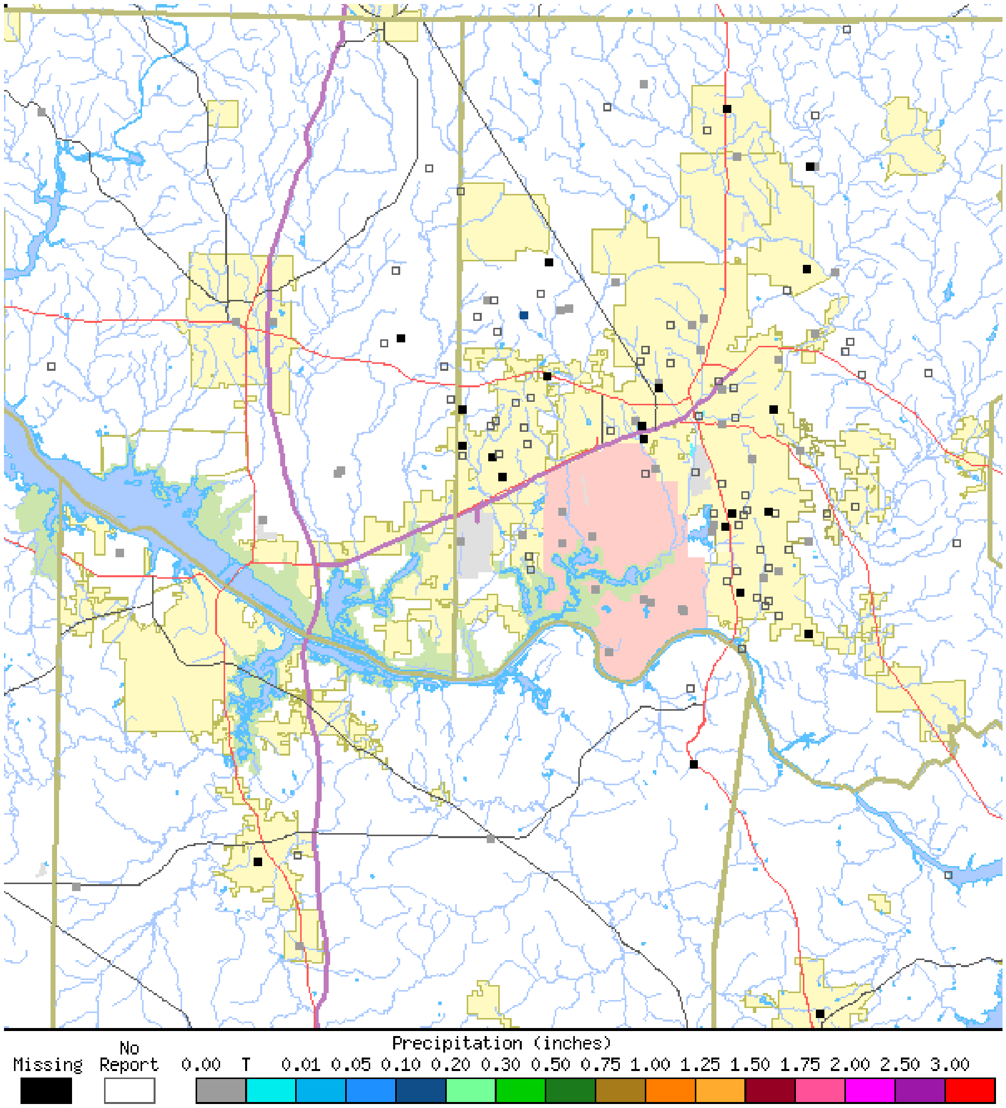


Figure 13. CHARM network coverage map as of June 2002.

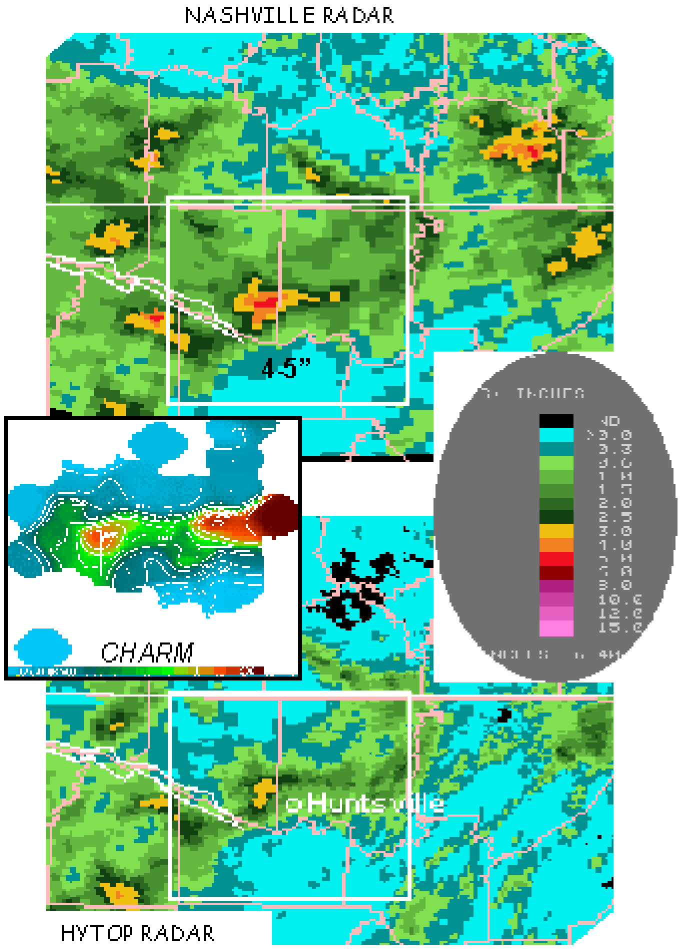


Figure 14. Nashville and Hytop storm integrated rainfall totals on June 4-5, 2001 over Northern Alabama. The CHARM insert shows ground truth validation data from a local rainfall network. Note that the dual precipitation maximum is not well resolved by either radar, and that the Nashville radar over estimates the actual intensity (less than 3.00").

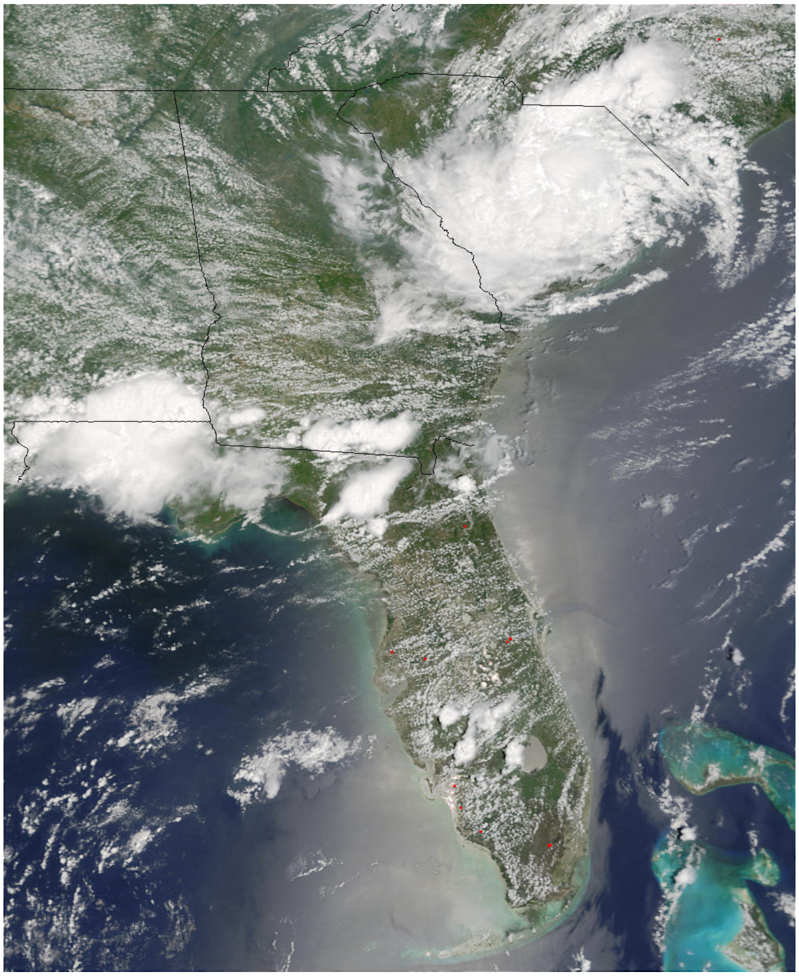


Figure 15. This true-color image of Tropical Storm Allison over the Southeastern United States was acquired from MODIS on June 13, 2001 MODIS. Many cloud and convective lines are evident as well as details of large convective systems. Red dots over Florida indicate points of active wildfires as identified by high-resolution imagery.

Table. A sample of satellite data and products applicable to short-term prediction

GOES	MODIS	AIRS	OTHER	GIFTS
Imager				
calibrated radiances	calibrated radiances, natural and false color composites	T(p)	Ocean surface winds	T(p)
insolation	Insolation	q(p)	Precipitation rates	q(p)
Albedo	Albedo	N(p)	Total lightning	N(p)
LST/SST	LST, SST			Winds (p)
Stability	Stability			
TPW	TPW			
Cloud height	Cloud products			
Winds	Vegetation state, NDVI			
wildfires	Surface thermal emissivity			
Sounder	Aerosols			
T(p)	Wildfires and smoke			
Q(p)	Dust			
Winds				
Stability				
TPW				
Cloud height				

Appendix

2002 NASA-NWS Joint Symposium on Short-Term Forecasting and the Convective Weather Warning Process

Participant Survey

The organizers of the symposium have created this survey to gauge the interest level, concerns and needs of the participants. We would very much like everyone to fill out this survey as your responses may be critical in determining the direction of future collaborative activities. Thank you for your time and effort in filling out this survey.

Affiliation:

NASA ____________ Media ____________
University ____________ Emergency Management ____________
NWS (Operations) ___________ Other (please specify) ____________
NWS (HQ) ________

1. From your perspective, what do you see as the top 5 short-term (0-12 hour) forecast issues affecting your area or constituency? (i.e., convective initiation timing, forecasting mode of convection, better precipitation forecasts, improved aviation forecasts, etc.)

2. What types of products, services or data sets (i.e., satellite, radar, NWP, etc.) do you currently utilize to address the issues listed above?

3. How do you envision that these current products and services could be improved to better meet your needs?

4. Are there certain problems or issues that affect your local planning and operations that you feel are not adequately addressed by NWS products or services? (i.e., excessive lightning deaths, accurate wintertime model QPF, onset of wintertime precip, etc.)

5. What type(s) of new products, services, or data sets would you like to see developed in the future to address your local planning or operations? (i.e., higher resolution NWP or satellite data, lightning warnings, etc.)

6. How do you (or can you) see the research and academia community better helping to address these issues?

7. How are you currently introduced or exposed to new products, services, or datasets? (Examples...publications, conferences, memos, "word of mouth")

8. From your perspective, how could you be better introduced to those products, services or data sets?

9. As end users, would like you like to see more detailed verification information? If so, what type? (Ex. verification by convective regime, storm type - MCS, supercell, etc., model versus model, forecast vs model, etc.)

10. Satellite data is generally underutilized. What factor(s) do you feel limit its utility (data access, scientific understanding, training limitations). From what you hear about available satellite date from SpoRT, what do you see as most useful?

11. What one element or issue does the NWS need to address in order to increase warning lead times and decrease false alarm ratios? (i.e. additional WES training, science training, better spotter network)